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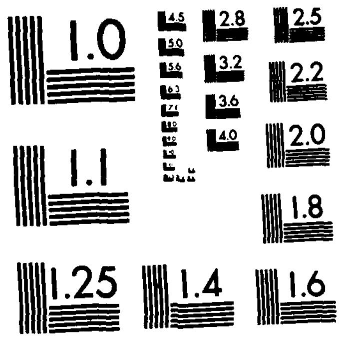

MICROCOPY RESOLUTION TEST CHART
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AUTHOR: K. LANGHANS

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CONCERNING SOME MILITARY-TECHNICAL ASPECTS OF THE NEUTRON WEAPON

[Langhans, K.; Zu Einigen Militaertechnischen Aspekten der Neutronenwaffe; Militaertechnik, No. 2, 1978, pp. 91-94; German]

In the past several months, much has been written in the domestic and foreign press about the American neutron weapon. The overwhelming emphasis was on the political aspects of this new means of mass destruction. And rightly so, for this weapon is a political issue which even divides the gods, a clear example of the aggressive character of imperialism, now as before, an example of its desperate attempts to turn the military balance of power to its advantage. /91*

Objectively speaking, the military aspects are currently not only of secondary importance, but also complicated, since little hard data have been released, and what has been released is partially contradictory. My observations are based on the most probable data. They are really just estimates and in part conjecture, since it would make little sense to try and make precise calculations based on nebulous data.

The concept, used in various publications, of "neutron bomb" is imprecise and useless, since it has, with exceptions, nothing to do with bombs. The term "neutron weapon" is more precise, even when freely translated from the American designation as a "nuclear explosive with enhanced radiation and limited heat and pressure effect."

In the following, the term "neutron weapon" will be used as an abbreviation for this designation. This is justified, since in this weapon neutrons play a dominant role in enhancing radiation.

1. History

Work on the neutron weapon has been going on in the U.S. since 1958 [1]. In 1962/63, initial publicity was given to the neutron weapon concerning its classification as a nuclear weapon system and also the possibility of its realization.

Development of the neutron weapon was considered possible. However, at the time, the military effectiveness of such weapons was extremely questionable, particularly in view of the much lesser accuracy at the time, among other things. This appears to have been changed with the subsequently developed neutron weapons.

The production of a W-75 shell with enhanced radiation should cost $452,000 [3]. With conventional nuclear or other modern weapons, the cost of attacking a circular target area with a radius of 1200 m is significantly lower, to be sure. However, new calculations have shown that the use of a neutron weapon--as long as no effective protective measures are introduced--will result in the capture of vast amounts of extremely expensive combat equipment (for example,

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*Numbers in right margin indicate pagination in original text.

aircraft, missiles, tanks). This possibility alone will be sufficiently attractive to give the defense economists in the Pentagon reason enough to conduct 15 to 20 years of active costly research.

In 1971, the military press printed the first references to nuclear explosives with enhanced radiation, which liberate 80% of their energy with spontaneous fast neutrons [4]. In a speech in 1972, the then U.S. Secretary of Defense admitted that the U.S. was indeed developing neutron weapons.

The opening salvo in the neutron weapon discussion during the past several months was a U.S. press report in July 1977 concerning a budget debate on financing the planned production of this expensive weapon. In this connection, one should not forget that the neutron weapon is only one result of the defense efforts of the military-industrial complex of the NATO countries during the past two decades. At least of equal importance and closely tied to the neutron weapon is the improved accuracy of guided missiles (cruise missile) and laser target acquisition technology (SNAKE EYE), based on microelectronics and other important scientific and technical advances made during this period [5].

As early as the 60s, the Pentagon and representatives of defense contractors were clearly seeking the development not only of nuclear weapons with great detonation intensities, but also progressively smaller nuclear weapons, which could possibly be used with conventional group means of mass destruction. In addition to the political aspects ("nuclear threshold"), this effort touches upon, though is not limited to, the fact that small (limited) targets near the front line must be engaged without unforeseen side effects, but also the military-economic reason that the target area for a nuclear weapon will not increase the detonation intensity.

With increased detonation intensity, the relationship between it and the target area will become even more unfavorable, i.e., with several low-detonation-intensity nuclear explosions applied in a checkerboard pattern a much larger area will be engaged (as well as many more target points) than with a large nuclear strike of comparable intensity. On the other side of the coin, however, it must be noted that the cost, mass and size of a nuclear weapon do not decrease linearly with a decrease in detonation intensity, since in any case, a detonation device is still necessary. Furthermore, only small detonation intensities are attainable with the conventional nuclear explosives uranium and plutonium, since their utilization is reduced to much less than optimal. Should it become possible to produce some as a nuclear explosive with a very small critical mass of usable transuranium (for example, 1-2 g of californium) in sufficient quantity and at a justifiable cost, this would open the door to the "mininukes" so long sought after by NATO and much discussed since 1973, the nuclear weapons with a TNT equivalent between 10 and 100 t.

But irrespective of the uncertainties surrounding the operational nuclear explosive, there are presumably 60 depots in the FRG where, since 1976, the U.S. Army has stored over 500 nuclear devices whose detonation intensity approaches that of the "mininukes" [3]. Evidently, the Pentagon intends to supplement these existing nuclear weapons with neutron weapons and genuine "mininukes."

In 1963 an underground neutron weapons test supposedly took place in the U.S., and a neutron warhead for the LANCE at the beginning of 1977.

2. Principles of Operation

It is known from previous publications that neutron weapons generate about 80% of their destructive energy with instantaneous neutrons, whereby the heat, light and pressure effect is reduced to about 1/10th of that of a conventional nuclear weapon of the same detonation intensity.

Now likewise with the "mininukes" and similar nuclear fission weapons with detonation intensities of under 1 kt, neutron radiation, together with gamma radiation, becomes predominant (determined by range), even though, as in the case of large nuclear weapons, the instantaneous nuclear radiation transmits only about 5% of the primary energy. This fact is clearly shown in Fig. 1. In nuclear fission weapons, however, the distribution of primary energy between neutrons and other energy sources cannot appear as 80 to 20, and the primary energy is not "enhanced", as in neutron weapons.

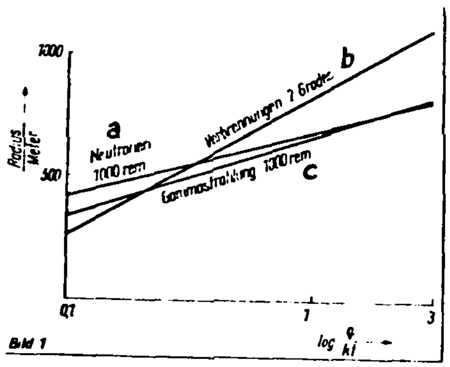

Fig. 1 A comparison of the effective radii of conventional nuclear fission weapons with detonation intensities of between 0.1 and 10 kt of TNT, with resultant neutron flux, gamma radiation, and second-degree burns (corrected, according to [3]).

a) neutrons, 1000 rem; b) second-degree burns; c) gamma radiation, 1000 rem.

In order to achieve the effects described in the literature, neutron weapons must be nuclear fusion (hydrogen) weapons, whose explosive power lies between 1 and 10 kt of TNT. So far it remains unclear how these small nuclear fusion charges are "ignited." It is hard to imagine that these are "pure" nuclear fusion weapons, and therefore that the required detonation temperature of several million degrees is attained without nuclear fission in the nuclear fusion charge. /92

We still are not aware of either lasers or implosion systems, or other methods, which as part of such a small warhead (or shell) could generate a sufficiently high energy concentration. Even using lasers to "heat up" nuclear fusion reactors (in which masses and size are unimportant) still misses 2-3 orders of magnitude [7].

One must assume that neutron weapons are detonated like large nuclear fusion or three-phase nuclear weapons with a nuclear fission charge. Because of the large critical masses of uranium and plutonium, their use for this purpose, though unfavorable, would still be possible, since only a very low percentage of the nuclear fission energy of this type of detonator would be used. Since only 0.1 to 1.0 kg of material (for example, deuterium-tritium) would be necessary to generate nuclear fusion energy of from 1 to 10 kt of TNT at a 20% utilization, the "donated" detonator would be heavier than the lethal payload.

In view of the construction and minimization of fission products, it would therefore be advantageous to use detonators from pure transuraniums.

The critical mass of a suitable californium isotope is supposedly only 1-2 grams. However, there is no known process by which such transuraniums can be manufactured in macroscopic amounts at a justifiable cost. The annual production in the U.S. is under one gram.

The question concerning the detonating mechanism for a neutron weapon can thus only be vaguely and speculatively answered. The only material certainly available, usable in practice as a detonation material, is plutonium. If actually used, then in a neutron weapon the generation of fission products must be assumed, in a quantity about 1/10 that of a nuclear fission weapon of comparable energy.

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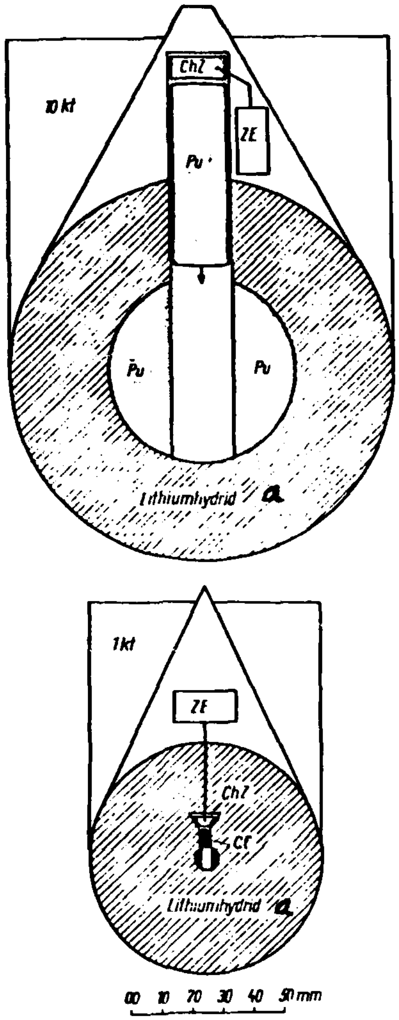

Fig. 2 Estimated construction variants of neutron weapons with plutonium or californium as the detonator for the nuclear fusion.

ChZ: chemical detonator; Pu: plutonium, ZE: detonation electronics, Cf: californium. a) lithium hydride.

Fig. 2 schematically illustrates, using a possible design model, the various ratios encountered using plutonium or californium. With the plutonium detonator, the ratios for a 10-kt neutron weapon were estimated, and for a 1-kt neutron weapon with a californium detonator. It is obvious that the less favorable variant of a certainly less than optimal design model can still be fired from a 155-mm barrel.

Regardless of the merely presumed construction of the neutron weapon, it is still possible to postulate somewhat concerning its anticipated destructive effect.

3. Destructive Effect

Data on the effects of the neutron weapon differ considerably in available sources. The effective ranges shown in Fig. 3 approximate the various data on the LANCE neutron warhead.

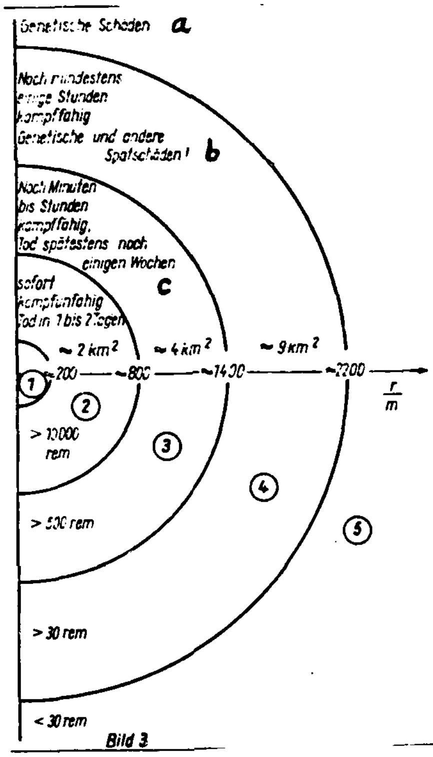

Fig. 3 Area-accented representation of the destructive and damaging effect of neutron weapons.
a) genetic damage; b) still effective at least several hours; genetic and other late effects! c) still effective for minutes to hours, death several weeks later at the latest; d) immediately ineffective,death in 1-2 days.

The W-70, modification 3 neutron warhead for the LANCE supposedly has a detonation intensity of 10 kt of TNT [3]. Of this amount, about 10% (1 kt) is consumed by the nuclear fission detonator in the usual proportions (50% pressure, 35% light, 10% residual and 5% instantaneous radiation). An additional 10% is released upon fusion in the form of pressure waves and radiated light energy. The remaining 80% then remains for the strong neutron flux and a portion thereof can be expected as gamma radiation. It should be noted that the spectral composition of neutrons in the neutron weapon is essentially quite different from that of the neutrons in a small fission weapon. The most effective is that hard segment of these neutrons, which with 14 MeV (megaelectronvolts) of kinetic energy has a high penetration capability. The initially highly-energized neutrons, on their way to the affected area, are scattered among the atoms of the atmospheric components, and thus partially

moderated into thermal energy. The then thermal neutrons react with the atomic nucleii of the atmospheric nitrogen in the following manner: $N^{14}(n,\gamma)N^{15}$. A secondary, hard gamma radiation arises in the affected area (in armor plating and other protective layers, in the human body...).

It is estimated that most of these gamma quanta with an energy of 5 to 6 MeV originate at a distance of about 500 m from the center of the explosion and generate 1,000 roentgens of gamma radiation with a 1-kt neutron weapon (and 10,000 reoentgens at 10 kt) [9]. Such estimates always entail inaccuracies. Fig. 3 shows not only the direct neutron effect, but also approximately the beiologically equivalent sum of neutron and gamma radiation damages inferred by H. J. Werner [9]. J. K. Miettinen's [3] declaration that the neutrons effect is limited to 1300 m cannot be accepted, since P. A. Jampolski [10] has applied an exponential function for the neutron range, which at this distance certainly does not discontinue. Now we see, more clearly, based on the estimate shown in Fig. 3, the effect of the neutron weapon, which its apologists describe as "clean" or even "humane". Within annulus 1 ($r \approx 200$ m), in addition to the immediately lethal nuclear radiation, pressure and heat have a destructive effect, similar to that of a nuclear weapon with a small detonation intensity ("mininuke"). Most important is annulus 2, whose outer limits can extend out to $r \approx 800$ m. Only within this annulus does the publicized immediate combat disabling of personnel occur (to be followed by a speedy and painful death), even when such personnel are sheltered behind steel armor (up to 10 cm), in light or open cover, or inside buildings (behind ordinary walls). It is /93 within this annulus that the double effect so dearly desired by those responsible occurs, in which personnel are killed rapidly enough, but the "hardware" remains largely undamaged.

The personnel in annulus 3 will also die, but only after several minutes to days. Frequently during this period, however, they can carry out a combat assignment.

Within annulus 4 there is at least a 50% probability of survival, and to the extent that an acute nuclear radiation syndrome sets in (radiation sickness), they will still be effective for at least several hours. But at any rate, within this annulus there will be genetic damage, which will have the most brutal consequences for several generations. Although in number and scope they are on a much smaller scale, the "thalidomide children" with their impairments illustrate these hideous consequences with great similarity. In addition, in annulus 4 we must reckon with a host of additional late effects--for example, a significantly reduced life expectancy, increased risk of cancer and general bad health.

Genetic damage may also occur in annulus 5, the external diameter of which cannot be given, as long as no threshold level for genetic damage due to nuclear radiation has been determined.

This picture becomes even clearer when one compares the areas of the annuli, approximately proportional to the numbers of people affected. This shows that roughly 2 km^2 with calculated effect confronts 13 km^2 with almost the opposite effect, as long as the neutron weapon is not used in massive numbers within 2-km grids in a checkerboard pattern. For the individually employed neutron weapon, we must assume, in any event, more than 6 times as many painfully affected casualties but combat ready for a longer period of time, as the number of those immediately (or at most within 5 minutes) incapacitated.

It should also be noted that, in annulus 2 alone; neutrons would have the same (lethal) effect on man as a biologically comparable dose of gamma radiation, and that they will have quite dissimilar effects on radiation-sensitive materials. This is easily misunderstood, since the biologically equivalent effect is given using the same unit of measurement, the "rem". And thus, for example, the recuperation of the radiation victims functioning in the survival zone proceeds more unfavorably (more protracted), and there will be a significantly greater and somatically irreparable, residual effect than, for example, indicated for gamma radiation [11].

Within their own spectrum (due to resonances at particular energy levels), neutrons will have varying, sometimes even totally different effects on nuclear radiation-sensitive materials than gamma radiation. This refers only to possible direct activation (for example, of tank tracks, various chemicals) and to the totally different attenuation mechanism. Because of space limitations, this topic will be reserved for a later discussion.

4. Possible Protective Measures

With regard to protection against neutron flux from a neutron weapon, on the one hand there are parallels to gamma radiation from "normal nuclear weapons", but there are also vast differences. Material as densely packed as possible and placed between the radiation source and the affected area offers the best possible protection against neutrons as well as gamma radiation. But because of the required mass, light materials (elements and their compounds or mixtures from the beginning of the periodic table) and special neutron absorbers, unlike gamma radiation, provide better protection than heavy materials. In addition, the scatter effect with neutrons is more pronounced (they fly more often "around the corner"), which, for example, is more advantageous behind a closed cover, but less advantageous in open ditches, than with gamma radiation.

At certain neutron energy levels, resonance capture could be used for neutron protective layers. For instance, in contrast, armor plate, which normally has a protection factor of 0.1 against gamma radiation, will only have a protection factor of 0.5 against neutron weapon radiation. However, this protection factor could be improved from 0.2 to 0.1 through the application of neutron-attenuating materials.

There are various possible specific protective measures against neutron weapons which could be introduced (and practiced) concurrently with the introduction of this new mass-destruction weapon. Here, however, as with gamma radiation, even costly research should not be expected to produce any miracle, perhaps in the form of protective clothing, but not because secondary hard gamma radiation occurs in the area affected by the neutrons. Protective measures against weapons of mass destruction are usually either active or passive. Since active measures against neutron weapons (for example, engagement of depots, bases, and means of attack) differ little from those used against conventional nuclear weapons, further discussion is superfluous.

Passive protective measures can be divided into technical and tactical (or action-related), whereby the technical measures mostly require a longer preparatory period (and creation of material conditions), whereas tactical measures can be utilized as soon as they are incorporated into the training process. Just a few examples of both groups can be presented here, and it will become necessary in

the future to thoroughly examine the problems of protection against neutron weapons in the military-scientific and military-technical activity of all components of the national defense.

In the case of technical protective measures, it is necessary to achieve optimal military economy and determine which protective layers are "bearable" in both senses of the word. In principle, it is possible to apply sufficiently thick protective layers to vehicles (at least to armored vehicles), ships (boats), installations and structures and thus achieve arbitrarily low attenuation factors and high protection levels (they express the ratio of the dose behind the layer to the protection in front of the layer; with them, without protection behind the dose is multiplied). With ships and structures, the degree of protection is thus mainly a question of material and financial means. But in view of their permitted axle loads, vehicles can for the most part be coated with only a few centimeters of protection. Table 1 gives an overview of the possible protective values of concrete. The attenuation factor for 2.3 m of concrete applies to neutrons with an energy level of 14 MeV [9].

Table 1 Protective values of cement against 14-MeV [9]

Cement thickness, in m	0.4	0.7	1.0	1.3	1.7
Attenuation factor	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}

Additional technical defensive measures consist therein that vehicles, ships, installations, and structures can be prepared for additional emplacement of protective layers as well as for protection through earth or water. For instance, shutters constructed from protective material or at least fitted at the proper time with fixtures for hanging protective layers can be installed, so that with acute danger from neutron weapons, the shielding factors can be rapidly improved. There are may other defensive measures to choose from: more logically underground or under water than ever before! This especially involves /94 all personnel and also installations, in which personnel are working, which contain materials sensitive to nuclear radiation. In the case of stationary military installations, underground construction is primarily a question of cost. But there are also additional field-fabricated options: for example, through improved engineering techniques, or equipping tanks so that they can, in exceptional cases, proceed under water to their staging area, where they constitute an especially good target for neutron weapons. As an example of the many special measures to consider in diverse areas, it should be noted that the future personal dosimeter should be suitable for sufficiently accurate measurement in the radiation field of neutron weapons.

Tactical defensive measures involve, for example, additional and more extensive decentralization of forces, better camouflage, deeper emplacement of combatants and vehicles, command posts and the like. Furthermore, it entails utilizing the neutron-protection properties of forests, valleys, and buildings; deployment of reserve service personnel for major installations with inadequate protection from neutrons; the improvement of protective works (for example, increasing the earthen cover over dugouts), the advantageous use of inner rooms (protected by multiple walls) in buildings, and use of shipboard compartments located below the waterline.

Up to now, every new weapon has led to the introduction of counterweapons and defensive methods. If the neutron weapon is indeed introduced into the NATO armies, against all humanitarian principles and common sense, then the socialist states will learn how to defend themselves promptly and effectively against it.

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